Response to the CALFED Science Program Review Panel Report to the Interagency Ecological Program Management Team regarding the 2005 Pelagic Organism Decline Synthesis Report and 2006 Draft Workplan

Introduction to this Response Document

The body of this document is comprised of two distinct but interrelated parts – (1) An independent Review Panel Report regarding the Interagency Ecological Program (IEP) POD Synthesis Report and Proposed 2006 Work Plan, and; (2) Program and Program Element Responses compiled within the IEP Pelagic Organism Decline (POD) Management Team. The Review Panel Report appears in its unaltered original font and formatting (12-point Arial, with **Bold** section headings). Responses from the IEP POD Management Team appear after the relevant section of the Report using highlighted font and formatting (***12-point Bold Italic Times New Roman***).

It is useful to bear in mind that the efforts herein described aimed at deducing the causes of the Pelagic Organism Decline are part of a larger federal and State-mandated program of monitoring within the San Francisco Estuary required of the Interagency Ecological Program. The establishment of trends in aquatic resources and the identification of issues related to accurate monitoring of the status of aquatic populations within the Estuary as they relate to State and federal Water Project operations are central to the IEP mission. There are many activities and ecosystem stressors impacting aquatic resources within the Sacramento-San Joaquin River Delta that, while important to document and describe, remain tangential to the role traditionally served by the IEP and its related cooperators. There are additional ecosystem drivers acting beyond the legal boundaries of the Delta which have importance at an ecosystem scale but which are beyond the IEP realm of responsibility. The IEP POD Management Team recognizes these realities and calls attention to the IEP's historical and contemporary support of so-called "special studies" of system-wide or subject-specific understanding for issues related to Delta and Estuary ecosystem health and function (see Attachment A: IEP-related Bibliography). IEP POD Management Team members (and the IEP more widely) recognize the need to continue to balance a focus on current "critical" water resource issues with a need to continually place Delta-centric issues in their proper ecosystem, watershed, and regional climatological context. We welcome discussions and proposals for enhanced collaboration in pursuit of integrated water resource and ecosystem management within the Estuary.

The Review Panel Report and IEP POD Management Team Responses begin below:

Science Panel Report & Interagency Ecological Program Response

Executive Summary

The review panel recognizes that addressing the issue of pelagic organism decline (POD) in the managed ecosystem and human-dominated watershed of the upper San Francisco Estuary (Sacramento-San Joaquin Delta) is a formidable challenge. We commend the Interagency Environmental Program (IEP) managers and scientists for seeking ways of balancing the needs for human use of the area's water resources with the survival requirements of other components of the ecosystem. The suite of problems in the Bay-Delta is of immense importance to California. Working under constant political scrutiny and demand for "instant results" the IEP has maintained a high-quality program that includes an invaluable long-term data set. The passion of the IEP employees for their program and the effort invested to make it succeed were very evident to the review team. When confronted with demands for more answers and political quick fixes to a deteriorating environment, the IEP produced a thoughtful and skilled response with a more elaborate research program that will hopefully reveal the underpinnings of the ecological disaster confronting the Bay-Delta. The review panel praises the IEP for a job well done and hope that our observations, comments and suggestions will be of assistance to the scientists and managers who are attempting to seek novel solutions to complex problems of critical resource management through this worthy program.

The IEP, together with the coordinating efforts of the California Bay-Delta Authority (CBDA), represents a unique collaboration of federal and state entities charged with the immense task of developing an understanding of the structure and functioning of the Bay-Delta ecosystem. Such a unique collaboration affords many opportunities and yet demands a high level of effort to make the IEP succeed. Such aspects as a well-developed management structure, regular management meetings, frequent informal communications and a clear reporting structure are the hallmarks of a good management approach. Each component of the IEP has an identified leader(s) and a clear set of management objectives that collectively point toward a thoughtful study program. The review panel commends the IEP for taking the necessary steps to make program management succeed. Further, we have the impression that management of the IEP is intended to serve the needs of the study program and not vice versa – a very healthy approach.

The review panel identified several strengths and weaknesses of the current program. These are summarized below and followed by summary recommendations. Subsequent portions of the report expand on these points and provide additional details and comments on specific projects.

Strengths:

- The program has developed a very substantial historical data base on important populations of pelagic and benthic organisms for the upper estuary and Delta. This provides the primary means for detection of changes in the ecosystem and is an essential source of insights into the possible causes for long-term decline of pelagic organisms.

- The management of the IEP appears to be working well and addresses many of the issues one could expect with such a complex collaboration.

- The research effort has been guided by a conceptual model approach with the potential to allow ideas to evolve as the information base is augmented.

Weaknesses:

- The program relies too heavily on local perspectives and resources for problem analysis, research and solutions. This can give rise to a culture of common assumptions that impedes exploration of alternative possibilities.

- The step-like decline in abundance of delta smelt and other pelagic species in 2001 has been interpreted as a recent shift in environmental or biological conditions, and is driving much of the recent research effort. However, the evidence is not convincing and the interpretation is open to question.

- Interest in understanding and presumably reversing the long-term decline in pelagic organism abundance in the Bay-Delta does not appear to be associated with specific restoration targets.

- Key pieces of basic information appear to be lacking on the habitat requirements and early life stages of pelagic species of interest. For example, there is very little information on where the eggs of delta smelt can be found in the system. Likewise, there are few reliable estimates of vital rates (e.g. stage-specific growth and mortality rates) required to adequately model spatially-explicit population dynamics of pelagic species under different scenarios.

- The data analyses and dynamic models lack the sophistication to match the complexity of the dynamics in the hydrological and population/community dynamics of the Bay-Delta system.

Recommendations:

• The IEP should consider a revision to its management structure to make better use of key academic partners in program decision-making. This should be done in a manner that avoids conflicts of interest yet provides a mechanism for input to management decisions from members of the academic community who are most knowledgeable about the Bay-Delta system. Seeking annual input from a small group of external advisors is one means of addressing this issue.

- ✓ ***The IEP has a Science Advisory Group (SAG) that is composed of individuals from the academic community. The stated purpose of the SAG is to provide guidance to IEP to do the right science. The SAG reports to the IEP Coordinators. The SAG has been used to conduct reviews of the San Francisco Bay/Delta Outflow Study and Environmental Monitoring Program. The SAG is conducting a review of the IEP delta smelt work this year and is scheduled to review the IEP delta juvenile fishes monitoring program next year. While IEP has used the SAG to revise and improve existing programs, IEP has not extensively used the SAG to help define future directions or to assist in setting priorities. These are two additional areas where academic expertise could be of assistance to IEP and they will be discussed by the IEP Coordinators. Inclusion of additional external personnel will need to be pursued carefully with regard to governance requirements (e.g. Federal Advisory Committee Activity requirements).***

- ✓ ***As a related issue, conflict of interest considerations could arise if academicians were included in IEP Management Teams (by potentially directing programmatic funds to their own research activities). Academic researchers are, however, regularly invited to give input through the IEP SAG, IEP and POD-related Work Teams (e.g. Estuary Ecosystem Team), at workshops, and via participation in special review panels. By integrating the activities of the CALFED Science Program into IEP POD Management planning the IEP group will increase opportunities for peer review and input.***

• The IEP is advised to make use of peer review at all possible opportunities in awarding and reviewing of contracts and grants. While recognizing that many high-quality studies have been supported in the past through these contracts and grants, the review panel recommends this step to assure that the best possible science remains a primary criterion of present and future work in the Bay-Delta.

- ✓ ***To the extent possible, and as demonstrated in the attached table (Attachment B), the IEP monitoring and analysis needs are coordinated with proposals chosen for funding via the CALFED Science Program Proposal Solicitation Package (PSP) process. Current grant funds made***

available for IEP-relevant work awarded under the auspices of the CALFED Science Program PSP process receive several rounds of peer-review and scrutiny for conformity to CALFED Record of Decision (ROD)-established goals and objectives. The CALFED Science Program will make available staff resources to facilitate independent review of study elements within proposed annual work plans as necessary. Additionally, the CALFED Science Program will make available via its Science Advisors and Independent Science Boards subject matter experts for reviewing specific IEP elements where needed.

- While it is recognized that conducting much of the research on this ecosystem is an explicit role of the resource agencies that constitute the IEP, extra-governmental assistance is needed in portions of the program. For example, external expertise may be sought to incorporate a strong spatially-explicit perspective into sampling protocols as well as in hypothesis development and testing. An open solicitation of proposals could be a valuable means of capitalizing on additional externally available expertise in these areas, particularly from within the academic community.

    - ✓ ***Closer integration of IEP Program Elements and CALFED Science Program Proposal Solicitation activities is anticipated and will be pursued in this regard.***
    - ✓ ***An on-going review of the IEP Red Book (governance document) will examine this recommendation and provide further input into IEP POD work plan refinement.***

- Key information gaps involving the natural history and population dynamics should be filled for species of special concern. Spawning habitat of delta smelt should be identified and data from the most successful population abundance surveys should be placed within the context of dynamic stage-structured population models. For example, the number and fecundity of adults caught in the Kodiak trawl allows a prediction of larvae at 3-, 6-, 9- and 12-mm size classes. A direct survey of eggs in natural spawning substrata would improve these estimates immensely. This could proceed to an escapement- and evasion-corrected sample of juveniles from the Fall Midwater Trawl survey. Existing index data are adequate to design this approach. The inter-stage rates then become the first draft estimates of a list of population vital rates for a model that will not tolerate ambiguity in a closed population like the delta smelt.

    - ✓ ***We agree that identification of spawning habitat would provide useful information and with the need to develop a stage-structured population model for each target species. We have the tools to calculate total adult fecundity and can potentially add sampling to assess larva size classes (currently larva sampling is surface-only during the late March through early July 20mm Survey and the 20 mm survey is effective only for ≥***

10mm larvae), but we are skeptical that egg surveys would be cost effective or likely to improve estimates of survival. If there is a specific method known for collecting adhesive eggs from unconsolidated substrate we would like to review it and possibly revise our thinking. We know of no such method as of this writing, and will support efforts by qualified researchers to propose such methods for review during upcoming Proposal Solicitation activities.

- ✓ ***Identification of spawning habitat can be accomplished using two trawls: 1) Kodiak trawl to identify congregations of ripe adults; 2) when these congregations become dominated by females, use short tow Otter trawling to locate males and spawning females, which are presumably close to spawning substrate. Examination of the Otter trawl for eggs and substrate samples from the trawl path can confirm spawning and characterize substrate.***

- ✓ ***We are also investigating tools to improve our trawl abundance estimates: 1) use of the Didson camera to estimate trawl mouth area and fish evasion and escapement rates (possibly by fish size); 2) improving estimates of cod-end mesh retention; 3) review incomplete analyses of fish evasion sampling for 20 mm nets and plan additional special studies.***

• Use of the DSM2 hydrodynamic model should be phased out in favor of a 3-D numerical modeling system. With regard to the biological components of the system, the habitat-quality monitoring program should be improved and expanded to recognize species-specific ontogenetic requirements within the structure of the landscape at multiple spatial scales. There should be targeted studies to elucidate critical habitat requirements of key species of concern. These recommendations are intended to provide a better foundation for future ecosystem modeling.

- ✓ ***Several candidate 3D modeling systems are being evaluated within the Estuary scientific community. Future Science Program funds might be used to target specific applications as test cases for the emerging models and expertise. The IEP is pursuing site specific habitat quality studies as part of its on-going study plans (i.e. the South Delta study that should be amenable to incorporation of the emerging hydrodynamic models).***

- ✓ ***This is an item for consideration by the CALFED Independent Science Board and the CALFED Lead Scientist. Increasing support for modeling efforts within existing Agency programs or supporting alternative modeling program establishment is under consideration as part of CALFED Science Program reorganization.***

SPECIFIC COMMENTS AND OBSERVATIONS

Programmatic issues – Review panel members had concerns that the input of the numerous external partners may be somewhat lessened by a management structure of the IEP that relies heavily on State of California and federal agencies. For example, few if any of the leads of elements within the IEP program come from the academic sector. Further it was not clear that academic participants play much of a role in the management of the IEP outside of their grants and contracts. Thus while relying heavily on university grants and contracts, the IEP may be overlooking the opportunity to derive decision-making input from the academic-based participants in the IEP studies. We suggest that the IEP develop a relationship with a few key academic partners that allows for input to the management of the program in a manner that avoids conflict of interests with contractors/grantees.

- ✓ ***See comments above, Page 4.***

In addition the review panel sensed that the IEP tends to utilize a few academic contractors that have a long-standing relationship with the program. While we saw no reason to expect anything but the highest quality from these studies, we were unsure if full peer review is used to evaluate the contracts/grants in these instances. To avoid any appearance of favored status with contractors/grantees, the IEP is advised to make good use of the CALFED Science Program for review and selection of science projects.

- ✓ ***Existing (and past) contractual arrangements have had some tendency to be relied upon in order to facilitate execution of new work without enduring undue contract-related delays. Contract-related difficulties when trying to hire academic specialists remain an ongoing hurdle for IEP and constituent Agencies. CALFED Science Program staff resources will be made available to explore alternative means for providing needed expertise to the IEP in a timely fashion. Governance-related review of IEP Policies and Procedures ("Red Book" review) is pending. Avenues for continuing Science Program support for IEP-relevant contracts are being identified for inclusion in CALFED reorganization priorities. This support should include guideline options for how academic specialists are identified and contracted.***

In a similar fashion, regular peer review of the long-term monitoring employed by the IEP is an excellent method to ensure that the best methods are brought into this vital part of the program. Excessive reliance on internal perspectives may inhibit creative thinking about complex scenarios (e.g., suites of factors that interact at multiple spatial and temporal scales) controlling the population dynamics of pelagic organisms. Due to the very challenging nature of the problems facing this managed ecosystem, a more open solicitation of ideas for creative solutions seems appropriate.

- ✓ ***IEP program elements undergo regular technical reviews which often involve independent peer review by the IEP SAG. The SAG recently reviewed the Bay Study (2000, Environmental Monitoring Program (2003)) and is currently charged with reviewing the Delta smelt program. We agree that other elements may benefit from comprehensive reviews. However, the monitoring program is partly dictated through regulatory processes and as such cannot be easily changed. Other elements have very long-term data streams so that even if they could be improved, the potential loss of the data stream must be considered carefully. Fiscal realities currently limit additional monitoring elements within the IEP budget structure. Some key monitoring elements have undergone useful peer-reviewed revision (e.g., Bay Study and Environmental Monitoring Program). We agree other elements could benefit from comprehensive review.***

- ✓ ***The use of formalized annual outside specialist review input to Program planning has been proposed and could be supported using CALFED Science Program resources.***

Research- and concept-related issues: The Delta Pelagic Species Conceptual Model has driven the program focus and analysis of existing data and was considered by the panel to provide an effective initial framework to guide an approach to resolving the issues surrounding pelagic organism decline. Plans to update and revise the conceptual model to incorporate spatially- and temporally-explicit variation in factors that would likely impact the growth, survival and reproduction of pelagic fish populations are strongly supported by the panel.

- ✓ ***We began this process using the matrix models in the synthesis report. We recognize the potential importance of this and expect scale considerations to factor strongly into synthetic analyses.***

The research supported under the program falls into two basic categories of (1) monitoring changes in the physical and biological environment of the Delta and (2) identifying the mechanisms driving that change. The first provides an indication of the past and present conditions in the system and the second provides the information required to direct any changes deemed necessary to achieve some desirable system state.

Exotic species effects are actually a subset of a broader category of tropho-dynamic effects that are considering changes in prey communities on which pelagic fishes of the delta are dependent. Water project effects and toxic effects have generally aimed to identify direct impacts on survival of the pelagic species of special interest, but water project effects also include some unspecified consideration for impacts on habitat suitability for pelagic fishes. Because habitat is defined by each species rather than being an arbitrary area that can be defined by physical watershed features or the presence/absence of other species, more

information on ontogenetic habitat requirements for the species of special interest may be necessary.

- ✓ ***We have considerable qualitative information on ontogenetic changes in habitat use by the POD species. This is currently either institutional knowledge (see Appendix from 2005 workplan) or described by Moyle (2002). One major focus for 2006-2007 is spatial analysis of fish and prey co-occurrence. This may help integrate the tropho-dynamic effects with our definitions of habitat.***

Although the current round of projects has been directed toward identifying the causes of a recently perceived 'step-change' decline in pelagic fish abundance, the historical record on pelagic species abundance indicates a persistent downward trend spanning more than two decades within the context of the record span (1959-2005). The currently identified 'step-change' may simply be one of a series of such events and the panel advises that the need to understand the proximate cause(s) of recent POD should not overwhelm consideration of the long-term record.

- ✓ ***See below (Pages 9 – 10, & 13 – Manly/Chotkowski inputs)***

Analysis of the abundance data that led to the conclusion of a significant recent step change was based on a single model that did not account for the dynamic nature of population variations. Also, a single source of data (fall midwater trawl survey) provided most of the evidence presented to support a recent general step decline in the abundance of pelagic organisms, while other data sources (e.g., Bay study midwater and otter trawls, fish salvage data) would not have led to the same conclusion. For this and other reasons, the results are not convincing. The question of whether such a shift occurred - or whether the apparent shift is simply part of the decline that has been occurring over decades - is important. The focus on a recent step-change has led to a search for causes and solutions in the immediate vicinity of the shift, while a focus on the historical decline would draw attention to long-term changes in the system.

- ✓ ***We used the Bay Study data to show that the problem was limited to the Suisun Bay/Sacramento San Joaquin Delta – not to suggest that species have not declined. The Bay Study data do indicate that striped bass and longfin smelt have declined. Delta smelt and threadfin shad distributions have less overlap with the Bay Study station array. The Suisun Marsh otter trawls show the species declines. The salvage data may not show the POD declines, but cannot be readily interpreted as abundance estimates for striped bass or the osmerids because their distributions do not always include the south Delta (Sommer et al. 1997).***

- ✓ ***A refined and statistically defensible definition of the 'problem' is being pursued by Manly and Chotkowski. They have recently submitted a***

manuscript describing a regression/bootstrapping approach to analyzing trend data for step-changes. We recognize that the current low abundance may be linked to longer-term declines. We expect that development of species life history models will be useful for analyzing trends over both long- and short-term time scales. In cooperation with affiliated scientists (Kimmerer, Jassby, Rose, Cowan, Loge) the IEP is reevaluating population trends over the last 20 years with regard to possible ecological 'regime' changes.

The issue of POD in the Sacramento-San Joaquin Delta has been a concern for decades, and the purpose of expending the resources to understand how the system functions is presumably aimed at managing the system in a way that yields water resources for human uses while maintaining some desirable biological community. Because POD has continued for so long, largely unabated, restoration of some former condition appears to be mandated. However, it is somewhat surprising that specific restoration targets are not explicitly identified. For example, what is the desirable range (upper and/or lower threshold) of abundance for delta smelt or any other pelagic organism of interest in the Sacramento-San Joaquin Delta? Restoration of any ecosystem requires a set of specific goals or targets in order to measure success or failure.

- ✓ ***The California Department of Fish and Game has the goal of restoring the striped bass population to 1.1 million adults in the short-term and 3 million in the long-term. No similar goals are present for other POD fishes.***
- ✓ ***The Anadromous Fish Restoration Program is tasked by the Central Valley Project Improvement Act to make "all reasonable efforts to at least double natural production of anadromous fish in California's Central Valley streams on a long-term, sustainable basis."***
- ✓ ***Restoration targets for anadromous fishes are identified in the United States Fish and Wildlife Service (1996) Native Fisheries Recovery Plan. Discussions between resource management entities regarding restoration targets for most fishes within the San Francisco Estuary have not been formalized.***
- ✓ ***As part of its ongoing and re-vitalized Programmatic efforts CALFED is developing a suite of Performance Measures and associated frameworks for assessing progress towards ROD-identified ecosystem and recovery objectives. Integration of performance evaluation into IEP data collection and synthesis activities will be pursued in collaboration with existing Science Program objectives and initiatives.***

Comments on Statistical Analyses

The statistical analyses conducted so far as part of the IEP program have tended to be relatively simple and exploratory in nature. In moving ahead, it will be

important to base the analysis of data on a scientific model of the ecosystem in the upper San Francisco Estuary. In broad terms, the situation in the upper estuary involves spatial and temporal environmental variations (e.g., in hydrodynamics, toxics, habitat quality, etc.) acting upon the vital rates (e.g., fecundity, mortality, etc.) of spatially structured, trophically linked community that is itself changing through species introductions. In such a complex situation, simple analyses – for example, those aimed at correlating one variable with another – may be uninformative or even misleading.

- ✓ ***The basis of the synthetic analysis in the 2006-2007 workplan is an exploratory (correlative) analysis, part modeling of past and future scenarios using models we anticipate can be developed, part GIS/match-mismatch analysis, and finally, literature review/documentation of study component linkages. We recognize the potential for scale-dependence (e.g., Kimmerer et al. 2005; Nobriga et al. 2005). We recognize that the relative importance of factors influencing recruitment has likely changed through time (e.g., Bennett and Moyle 1996: Kimmerer et al. 2000; 2001).***

Even interpreting variations in the abundance of a single population must rest on an understanding of its population dynamics. The analyses that identified step changes in the abundances of delta smelt and other pelagic organisms were based on a statistical model that failed to account for even the simplest kind of population dynamics in which abundance in one year depends on abundance in the previous year. Dynamics of this kind can give rise to an apparent step change in abundance without involving a shift in vital rates.

- ✓ ***In general, stock-recruit relationships in the POD species are weak. We recognize this is typical of fishery populations and acknowledge that some form of stock-recruit analysis may be necessary for appropriate data interpretation (e.g., Bennett 2005). However, we have often seen stronger flow effects on age-0 fish abundance (e.g., Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002) than stock-recruit effects. Thus, the papers mentioned above have generally ignored stock-recruit (except for striped bass because it is relatively long-lived). Interestingly, in the case of striped bass, reliance on a form of stock-recruit (egg-juvenile survival estimates) has resulted in a clear step-change in relative abundance coincident with the* C. amurensis *invasion to be overlooked in the recent literature on striped bass population dynamics (Kimmerer et al. 2000; 2001; Kimmerer 2002). In the case of longfin smelt, historical length data from the Fall Midwater Trawl (FMWT) were not sufficient to develop stock estimates. Bay Study and Chipps Island trawl data from the 1980s and 1990s on, respectively, can now be used to estimate adult numbers.***

The basic model used in the analysis to test the significance of a step change

has the form:

$$\log Y_t = f(t) + \varepsilon_t \qquad (1)$$

where is catch per unit effort (CPUE) in period *t*, *f*(*t*) is a polynomial function of time that can include a step function, and $Y_i \varepsilon_t$ is a normal error with mean 0 and variance. As an aside, the time of the possible step change is identified based on the data, but is left explicitly unspecified because it is recognized that using the same data to hypothesize and test for a step is inappropriate. This is a mildly tricky point and more could be done here. For example, it should be possible to test for a step change at an unknown time that is *common* to all species. σ^2

One could also argue with the use of principal components analysis to derive an index series for a multi-species complex, but the main concern remains the form of the model in (1). A basic assumption is that CPUE is proportional to abundance. This is a common assumption but may be worth a more detailed look. The assumption that CPUE is proportional to abundance may not be correct for schooling fish, especially when abundance is low. Even if the proportionality assumption is correct, changes in the sampling methods over time can affect the constant of proportionality. For the present, however, CPUE is assumed proportional to abundance and is treated as abundance. Y_t

A simple model for the dynamics of a fish (or other) population is:

$$Y_t = Y_{t-1}\, g_{t-1}(Y_{t-1}) \exp(\varepsilon_t) \qquad (2)$$

where *g* is the growth function. This model can be written as:

$$\log(Y_t / Y_{t-1}) = h_{t-1}(Y_{t-1}) + \varepsilon_t \qquad (3)$$

where *h* = log *g*. Consider the simple case:

$$g_{t-1}(Y_{t-1}) = \exp(\beta_o + \beta_1 (t-1)) \qquad (4)$$

where the growth function does not depend on abundance (i.e., density independence) and is log linear in time. Substituting (4) into (3) gives:

$$\log(Y_t / Y_{t-1}) = \gamma_o + \beta_1 t + \varepsilon_t \qquad (5)$$

where $\gamma_o = \beta_o - \beta_1$. Thus, it is the annual growth rate that is a linear function of time, not log abundance as in (1). $\log(Y_t / Y_{t-1})$

For these and other reasons, the reality of the step change remains open to question. This issue is central to the design of the IEP program. If a step change in vital rates did indeed occur, then it makes sense to search for environmental or other changes that occurred immediately preceding the change. On the other hand, if no such step change occurred, the question as to its cause is moot and research should focus on the causes of the long-term decline.

- ✓ ***These recommendations are analogous to the Manly/Chotkowski approach. Their work is forthcoming and suggests a significant step-change occurred after 1998. Since the POD species FMWT indices did not recover substantially in 2005, we now have enough years of data to suggest a significant decline since the late 1990s even using conservative rank statistics. As for the long-term declines, the major factor for phytoplankton,* Eurytemora sp.*, mysids, striped bass, and longfin smelt, the major long-term trend is a step-decline roughly coincident with the* C. amurensis *invasion. Numerous* C. amurensis *impacts have been described in the peer-reviewed literature (e.g., Alpine and Cloern 1990; Kimmerer et al. 1994; Kimmerer and Orsi 1996; Orsi and Mecum 1996; Jassby et al. 2002; Kimmerer 2002; Feyrer et al. 2003) and more are forthcoming. Delta smelt and threadfin shad relative abundance does not appear to have been affected noticeably by* C. amurensis*; however, size at maturity for Delta smelt decreased substantially after the invasion of* C. amurensis*, likely resulting in an overall reduction in total fecundity. The current thinking is that only modeling approaches can elucidate the delta smelt abundance trends because they are not clearly linked to flow, exports, clams, or any other known system driver (Bennett 2005).***

More generally, in using historical data to infer the effect of an environmental variable on a biological population, it is important to go beyond simply attempting to establish a correlation between the environmental variable and abundance. Instead, inference should be based on an understanding of the direct effect of the environmental variable on population dynamics (e.g., on one or more vital rates) and how this direct effect would be reflected in abundance. As noted, when several factors are operating simultaneously, in identifying the effect of one, there is a need to control for the others through multivariate methods.

- ✓ ***We agree in principle. However, we are dubious that multivariate techniques can sufficiently 'control' the influences of co-varying factors. That is why environmental management has focused on system driving variables like flow or X_2 (Jassby et al. 1995) and exports. It is possible that understanding the mechanisms that underlie the fish/flow relationships would improve estuary management (Kimmerer 2002). However, it is likely the mechanisms differ for each species, so too much focus on species-specific mechanisms might result in a loss of focus***

from the big picture.

The review panel has a particular concern over the need for more spatially explicit data analysis. On the technical side, even when interest centers on average or aggregate quantities, there is a need to understand spatial variability to average or aggregate in an optimal way and for constructing confidence intervals or other measures of uncertainty. Furthermore, an understanding of both spatial and temporal variability is needed for efficient sampling design. More generally, spatial patterns in the variations over time in environmental conditions, vital rates, etc. are likely to be useful in distinguishing between alternative hypotheses about the factors contributing to the decline. The regional perspective outlined in the 2005 IEP synthesis report is a good step in this direction.

- ✓ ***We agree. As noted, spatio-temporally explicit approaches will be a major focus of our upcoming and synthetic data analyses.***

Comments on Contaminants studies

There is a paucity of historical data on contaminants and their potential effects in the Delta region of the San Francisco Estuary due to both the resistance of some government agencies to more actively investigate them and in the long held belief of many agency biologists that the existing problems in the Delta were due to other factors. So, turning belatedly to contaminants as a potential major factor in the decline of fish populations raises formidable challenges both from lack of historical data and construction of imaginative approaches to answering the obvious but difficult questions. Due to lack of attention, the thinking about these problems has not matured too far in many quarters. For example, there is an undue reliance on short-term survival bioassays, which were developed for regulatory tools in water quality management with no guarantees that they do indeed identify low-level chronic effects over multiple generations. These assay results may or may not be relevant to long-term toxicity, but there is a significant chance that any toxic problems from long-term, low-level exposures will not be manifest in or linked to such assay results. It is evident that some of the UC Davis biologists have taken seriously the possibility that long-term, sub-lethal effects are having effects and have produced some excellent studies and publications in this area. Most of these studies have included histopathological analyses with an emphasis on parsing the findings between toxic impacts and amounts of storage products available (e.g., glycogen) for various energetic demands. The histopathology findings will be useful only if they point to the life stage and mode of impairment caused by contaminants. Other studies can then be designed to measure changes in survival, fitness, growth and reproduction, as appropriate.

- ✓ ***Though we agree with the Panel's finding of lack of data, we disagree partially with the reasons. Key enforcement of the Clean Water Act falls***

on the U.S. Environmental Protection Agency, and through delegation to the California State Water Resources Control Board (SWRCB) and Regional Water Quality Control Boards. It has been a lack of State funding and available expertise that has limited the development of assessment tools and toxicity data within State agencies. The IEP agencies are guided by a mandate to assess the impacts of the water projects on the Estuary. As a requirement under SWRCB Water Rights Decision D-1641 monitoring has expanded into an assessment of the overall health of the Delta in order to discern effects attributable to the Water Projects. The high cost of contaminants effects monitoring, particularly potential chronic effects, coupled with the fact that the source of these contaminants is not identified as being associated with State or federal water projects has discouraged participation by the IEP.

- ✓ ***As far as the assessment of the likelihood that acute effects are contributing to the POD, we cannot argue the points made in the Review Panel comments. It is much more likely that chronic rather than acute effects will ultimately prove most pertinent to the decline in abundance of pelagic organisms. But due to the lack of any acute toxicity data, our general approach using short-term bioassays should be thought of as a first-step in which we look for obvious 'smoking guns' like major zooplankton and/or larval fish mortality in key times or places, rather than as a holistic approach encompassing the suite of potential contaminant problems. Moreover, we plan to investigate use of RNA:DNA ratios (growth index) both in bioassays and from field collected fishes that might identify periods and places where growth is inhibited. Findings of reduced growth will instigate further investigation of water chemistry to identify antagonistic constituents. Such growth ratios may or may not be applicable to stage based models, but should detect immediate contaminant effects.***

- ✓ ***We also recognize potential limitations in the application of biomarker results to life history models. Therefore, one of the recommendations in the workplan is to request that the CALFED Science Program assemble a panel of experts to provide expertise and direction on the value and use of biomarkers, including chemical and histopathological markers in determining the cause of the effect, and potential population effects. There is some value, however, in continuing the spatial comparison of biomarker presence in pelagic organisms. The state of knowledge for chronic toxicity effects in the estuary is so depauperate that even the unambiguous recognition of high (or low) frequency contaminant damage in multiple fish species would be an important finding.***

Looking for alterations in survival, fitness, growth and reproduction of delta fish species due to low-level exposures to biologically active mixtures of contaminants is the most productive approach to this potential aspect of the

problem. This top-down approach will also yield data that can, in theory, be linked to other data needed by population modelers and possibly show where other factors can interact with contaminants, a possibility that we need to anticipate. The challenge is to link what has or can be done on alterations of normal biochemistry, physiology and anatomy to their ultimate contributions (positive or negative) to the population trajectories.

- ✓ ***Though the approach listed above has logical merit, because of the very diverse land uses within the Delta watershed, the number of potential contaminants, and the permutations of mixtures would make this proposed research infeasible. One factor antagonistic to a contaminants-based POD theory is that, except for pyrethroids, use of known high toxicity pesticides is declining. The challenges of tracking pyrethroids due to their hydrophobic nature, complex and unknown transport mechanisms, and distance from application source to the Estuary make routes of exposure and effects difficult to understand, simulate, and evaluate. The strategy applied for the 2006-2007work is what we are calling "bottom up" (due to where the pelagic organisms reside in relationship to the contaminants flow) where effects seen in the organisms of concern will provide additional research direction on what specific contaminants might be suspect. In the case of chronic or sub-lethal effects, the need for the above mentioned expertise and direction in the use of biomarkers is critical. This is coupled with a "watershed down" approach, where if acute toxicity is observed, Toxicity Evaluation Identification (TIE) processes are applied to identify sources and loads of identified compounds.***

- ✓ ***In the realm of long term needs, adequate funding for programs such as the SWRCB Surface Water Ambient Monitoring Program (SWAMP) will provide mandated agencies with resources to evaluate the toxicity, sources, and loads of contaminants of concern. Emerging contaminants of concern, such as endocrine disrupters, will require additional focused research.***

- ✓ ***Having identified these issues, however, we agree with the approach presented by the Review Panel and envision a stepped process to investigate effects of low-level exposure. Still in 'triage mode,' we propose to use the bioassay and field growth indices to identify specific water collections that contain the biologically active mixtures affecting fishes. These mixtures, once identified through the TIE process and supported by literature as potentially causative agents can be tested further in (as yet unproposed) studies of long-term effects.***

EXPANDED MONITORING

Overall expanded monitoring of the Bay-Delta is a very good idea. The review panel suggests that substantial consideration be given to enhanced spatial sampling to complement the current long-term temporal sampling program.

- ✓ ***The estuary is intensively sampled from a spatial perspective. The scope of the analyses to date, rather than the nature of the data, has limited the results to temporal trends. However, some IEP program elements have or are in the process of enhancing their spatial sampling designs including the Delta Smelt Larvae survey (see below) and the benthic element of the Environmental Monitoring Program. Monthly benthic monitoring at relatively few fixed stations will be complemented with spatially-intense annual or semi-annual monitoring using a stratified, probabilistic sampling design. Among other benefits this will enable better estimates of clam (*Corbula amurensis *and* Corbicula fluminea*) grazing rates on a Delta-wide and regional basis, and thereby help investigate the "Bad Suisun Bay" hypothesis.***

Delta smelt larvae survey – Expansion of surveys designed to assess abundance of early life stages of delta smelt and the other species of special interest are encouraged, if feasible. Although the addition of the surface nets for collection of larvae was considered feasible and efficient, this was largely because augmented sampling did not add significantly to survey duration. Relatively few larvae were actually captured. Perhaps additional consideration should be given to sampling locations for larvae and other early life stages (e.g., eggs). Ontogenetic shifts in habitat use are likely (i.e. the entire life history of some species, such as delta smelt, is not wholly spent in the pelagic environment), and sampling methods should consider issues such as location of spawning sites (e.g. where in the system, whether submerged aquatic vegetation is important), and whether current sampling methods are adequate and appropriately located to assess the abundance of early life stages for this and other species of interest.

- ✓ ***Repeated attempts to sample for delta smelt eggs from areas that have produced high hatch-up larvae abundance have failed. High densities of hatch-up larvae have been found throughout the upper estuary suggesting delta smelt do not have stringent spawning substrate requirements. Based on limited egg sampling in vegetation and the results of lab studies on spawning substrate preference, it is unlikely that delta smelt spawn extensively on vegetation. Rather, it appears they prefer hard spawning substrata like rocks. Given these concerns, we are dubious that a field survey for egg abundance would provide more accurate model inputs than simply applying fecundity estimates to population estimates. We acknowledge that the same argument could be leveled at a larval survey with low catch. However, delta smelt spend most of their lives (i.e., hatch-up larvae through migrating adult) in pelagic, or at least open-water environments, as do other estuarine***

osmerids (e.g., longfin and rainbow smelts). In summary, open-water trawls have been the only reliable method for collecting all post-hatch life stages of delta smelt.

Summer townet survey – The fact that indices of abundance for both striped bass and delta smelt were at or near historical lows may not reliably indicate the direction of the actual population change because the values are not likely to be distinguishable from zero even if they doubled. Once the populations reach the low levels achieved in recent years, one would not expect to observe a rapid increase in abundance from such a low standing stock, especially with delta smelt which have a relatively low fecundity for a small pelagic species. Even population growth rates that are increasing exponentially are difficult to detect at the low end of the population size curve. One would not expect the abundance indices to be sufficiently sensitive to measure an increase or decline at such low levels. For example, given that the abundance index for delta smelt currently stands at 0.3, the value would have to quadruple before reaching even 10% of the mean values observed in the 1960s and 70s. At these low levels, the populations are in 'stealth mode' and it will be very difficult to determine the direction of changes in abundance with any reasonable confidence.

- ✓ ***We agree with the 'stealth mode' analogy and we are not currently putting tremendous stock in index direction from year to year. However, wet weather following dry weather historically has resulted in substantial 'rebound' of abundance indices. Even for delta smelt this occurred in 1992-1993 and then again in 1994-1995. The return of wet weather in 2005 did not result in a rebound for either delta smelt or longfin smelt, though it may have slightly for striped bass and threadfin shad. We remain concerned that something has changed recently that limits 'rebound.'***

Fall midwater trawl (FMWT) – This is the longest and most consistent of the time series data describing abundance of pelagic species of interest. It is expected that the FMWT surveys will continue to build on the historical database. Although the annual index for 2005 awaits the completion of the September to December survey set, it seems likely that the delta smelt and striped bass populations will remain perilously low. Whatever the cause for the pelagic organism decline, this situation requires constant and consistent attention. With the progressive decline in the number of tows yielding fish, the FMWT surveys have suffered a decline in precision, such that it may be difficult to detect even relatively large proportional changes (i.e. an increase or decrease of 100% of a small number is still a small number). Even as knowledge about the threatened species improves and as quantitative and regional approaches begin to replace the index, these rigorously standardized tows and sample patterns will continue to contribute to tracking broad scale trends in population abundance of pelagic organisms over the long term.

- ✓ ***We agree. Recent data suggest that species like striped bass and longfin smelt will exhibit even larger increases in abundance (several hundred to thousand percent) given favorable conditions.***

Other focused sample collections – feeding habits and condition, histopathology and *Microcystis* studies – These studies were a natural extension of perceived needs for information and should be completed. The continuation of a program of focused studies to address information gaps as they arise is encouraged, but caution is advised to avoid chasing causes of short-term variation at the expense of understanding the large-scale trends in system changes. Most of the focused studies are expected to provide discrete packets of information necessary to address specific information gaps over a finite period and should not normally be considered long-term or continuing contributions to the program. Some of these should focus on habitat quality, specifically with respect to aspects of life history features that are poorly understood (e.g. delta smelt spawning sites).

- ✓ ***See comments above (Pages 5-6 & 9).***

ANALYSES OF EXISTING DATA

Additional analysis of existing data is highly encouraged. The collective sense of the review panel is that the IEP databases contain a lot of good information that can greatly help to "connect the dots" in the POD. Further, the review team senses that the current staff of the IEP is running as hard as they can to keep up with the challenging situation in the Bay-Delta. Thus to make good inroads into the analysis of existing IEP data, additional staff should be brought on board to either relieve staff from current activities or to undertake the additional data analysis.

- ✓ ***We agree.***

- ✓ ***Science Program support for additional data analysis and analysis-related modeling research is ongoing through Science Program PSP funding and the California Sea Grant College Fellows program. These efforts are slated to continue into the future and solicitation for specific proposals for 2006 (for funding period 2007-2010) is pending. Input from the CALFED Independent Science Board will also be incorporated into these efforts once that body is reconstituted (expected 2006).***

Summarize the spatial and seasonal presence of early-life stages of pelagic fishes and zooplankton – The seasonal presence data provide a good measure of when to expect the various life stages of each species in the estuary, but there appears to be less information on spatial habitat requirements, especially for spawning habitat of fishes. This may be of particular importance in the case of

delta smelt, which have demersal eggs – the survival of which may depend on submerged aquatic vegetation or shallow waterways associated with intertidal habitat. The review panel had the impression that other likely spawning substrata (e.g. clean cobble or pebble beds) were uncommon in the system. Are the data on spatial requirements – in terms of habitat for early life stages – comfortably complete?

- ✓ ***We do not have a working definition of either delta smelt or longfin smelt spawning habitat. Consequently, we have no information on the spatial distribution of the habitat, the potential that insufficient habitat might limit reproduction, or whether the habitat has been recently degraded..***

Apparent growth rates of pelagic fishes and relationships to abundance -- Growth rates based on length frequency distributions over time can be misleading under conditions of different sources of size-specific mortality. The apparent growth rates from this method seem unrealistically high (1.2-3.7 mm/day), as is often the case using this method. The analysis of growth based on otolith data should help here. In fact, growth data estimated from otolith analysis puts growth (0.34 – 0.37 mm/d) at almost an order of magnitude lower than that derived from size frequency data. Although otolith analysis is not without problems (e.g. still applies only to growth of survivors), growth data from this source provide more reliable and realistic measures of growth rates within a cohort. The review panel recommends this approach over continued use of size frequency to estimate actual fish growth rates, though recognizing that analysis of size frequencies are quicker, less expensive and can provide a useful means of comparing spatial and temporal variation in relative growth rates. Perhaps there could be a focused study on individual growth rates using marked (ferromagnetic tags) fishes in different parts of the estuary. This may be more feasible for striped bass than the smelts or shad. It may also provide data on movements of individuals within the estuary, which will assist in refining the spatial extent of habitat for each species.

- ✓ ***We acknowledge the limitations on use of apparent growth rates and we have proposed to increase the use of otolith-based growth data – particularly for delta smelt. However, we believe the within-survey growth rates (20mm for delta smelt and longfin smelt; Bay Study and Suisun Marsh for striped bass) to be reasonable and useful; for delta smelt they're comparable to otolith growth rates. The between-survey (Summer Townet to FMWT) growth rates, those identified above as providing unrealistically high values, will be dropped. We think there are a few basic questions for which apparent growth data may be extremely informative. These analyses have not been included to date, but are: (1) Does the variance around mean fall size of striped bass suggest the increasing trend is due to more rapid growth (i.e., recent year variance is comparable to historical variance) or to greater size-***

selective mortality (i.e., recent year variance is considerably less than historical variance)? (2) Are the mean fall lengths of longfin smelt related to X_2 and did the variance pattern change after the* C. amurensis *invasion?

Zooplankton fecundity and population structure – Monitoring the quantity and quality of the food supply available to pelagic fishes and understanding the factors responsible for temporal and spatial variation in this crucial resource for pelagic fishes is important. However, the level of resources necessary to provide crucial information on zooplankton populations is largely determined by whether this group is included among the specific pelagic organisms of concern or is viewed as a prey resource for pelagic organisms. Measures of fecundity and population size structure of these populations, if viewed as prey, may provide more detail than is necessary at this point to identify the proximate factors responsible for changes in pelagic community structure and abundance.

- ✓ ***Our interest in zooplankton vital rates relates to the "Bad Suisun Bay" Hypothesis. Ultimately, we hope to model* C. amurensis *influence on the population dynamics of 'good' and 'bad' zooplankton prey. These analyses also may shed light on what suites of factors may contribute to prey resource declines. We are currently updating our stomach contents data to better define 'good' versus 'bad' prey.***

- ✓ ***Increasing attention to pelagic food web and related ecosystem dynamics will demand decisions regarding how much effort the IEP POD Team can put to maintaining existing monitoring programs and how much effort it can "spare" to pursue additional "special projects." Historically, the IEP has effectively enlisted locally-available academic collaborators to pursue additional analysis or sampling protocols. It remains to be seen whether these existing arrangements can continue to fulfill identified analysis needs or whether additional resources, researchers, and contracting mechanisms will need to be identified and utilized.***

Toxic and other harmful effects of Microcystis aeruginosa blooms – The occurrence of *Microcystis* and other harmful algal blooms (HAB) may be more symptomatic of changes in turbidity/light levels or nutrient inputs with the Delta system. Blooms do not appear to be sufficiently widespread to be a feasible explanation for either the long-term or recent step-declines in pelagic fishes. Though worthy of pursuit as part of monitoring the larger system-wide changes that continue to occur in the Delta, HAB may be considered an additional symptomatic response to environmental stressors associated with human uses within the watershed. Studies of *Microcystis* should be completed as planned but if expanded in the future should be aimed at providing information applicable to the control of HABs in the system, with less emphasis on their effects on other

components of the biological community, which can reasonably assumed to be negative. An additional useful perspective is to view *Microcystis* toxins as one a number of stressors that fish populations may face.

- ✓ ***Funding for a Proposal to examine these issues is being finalized within the CALFED Science Program. This research will be coordinated with broader systemic IEP monitoring efforts, and will be used to examine future potential investigations into HABs within the Bay-Delta ecosystem.***

Use and toxicity of pyrethroid pesticides - It appears that pyrethroid insecticides are increasingly finding their way into the Delta from urban development and agricultural activities in the Sacramento-San Joaquin watershed. One might expect the toxic effects of these compounds to manifest in the primary prey communities (small crustaceans) of pelagic fishes before they reach levels that are sufficiently toxic to cause direct mortality of fishes. As these compounds represent only one group of contaminants that are expected to affect the biological communities of the Delta in the future, it may be less important to describe their specific effects in the system than to seek ways of reducing contaminant inputs to the Delta. However, given the known sensitivity of fish and invertebrates to pyrethroids and their increasing use in the watershed, this would be a good time to rapidly determine whether pyrethroid concentrations are involved in, or can be ruled out as, playing a major role in the recent POD. Without chemical measurements at key points in the environment where these compounds are suspected of having effects little progress can be made. Expanded, integrated chemical measurements of pyrethroids may be necessary to resolve their potential role in toxic effects as well as to raise awareness of other chemicals that may be having effects.

- ✓ ***As stated previously, the challenges of studying pyrethroids given their hydrophobic nature, complex transport mechanisms, and the distance from large-scale pyrethroid application to the Estuary make routes of exposure and effects difficult to understand, simulate, and evaluate. The recent establishment of an IEP Contaminants Satellite Team provides a link with current researchers working on pyrethroids monitoring, transport, and fate. We agree that effects on invertebrates should be more readily apparent than effects on fishes. Potential sediment transport might indicate effects may be seen in benthic organisms as well. That is part of the rationale behind our support for comprehensive invertebrate ambient water bioassays. We are interested in determining whether contaminant concentrations are sufficiently high to directly kill invertebrate prey resources or reduce growth, and if so, when and where? Benthic monitoring programs are being redesigned to include not only speciation, but biomass. This can provide an indication of potential effects on benthic organisms. The toxicity identification and evaluation (TIE) procedures that follow a toxic assay result will identify***

contaminant constituents.

- ✓ ***Any pertinent results that indicate contaminants are a source of concern will be made available to those agencies that regulate contaminant loading. There are many compounds that could cause ambient water toxicity. We are not prepared to emphasize pyrethroids in particular until we determine whether invertebrate toxicity is a common occurrence in Delta water.***

- ✓ ***IEP and CALFED Science Program funding has recently supported development of the first Bay-Delta relevant "white paper" on pyrethroids within the system. The IEP-directed Contaminants Satellite Team is currently developing rationale and scope of work for directing research into this topic. Further Science Program funding may be warranted as part of the emerging PSP finance cycle and is yet to be determined.***

Use and toxicity of aquatic herbicides – One question that did seem to be considered with respect to aquatic herbicides is whether or not submerged aquatic vegetation (SAV) is providing a positive or negative habitat function for the early life stages of pelagic fishes. Is it worth considering the potential effects of herbicide use on spawning habitat of delta smelt or other species of interest? Spawning habitat and spawning substrata used by delta smelt in the Sacramento-San Joaquin delta region is unknown and a significant information gap in the life history of this species (see p. 13 and p. 59 in Bennett 2005, San Francisco Estuary and Watershed Science 3(2):1-71). If either shallow subtidal or intertidal vegetation play a role as spawning habitat for this species, it could provide a link between essential fish habitat and the application of aquatic herbicides, even if there are no lethal direct effects of the herbicides or the carrier compounds (e.g. surfactants) on the fishes.

- ✓ ***The SAV in the Delta is principally Brazilian water weed,*** **Egeria densa,** ***and is a major habitat for centrarchid fishes and a few other non-native species that co-evolved with centrarchids (Brown 2003; Grimaldo et al. 2004; Nobriga et al. 2005; Brown and Michniuk in review). It has proliferated during the past 25 years in association with native fish declines (Brown and Michniuk in review) and its success is likely a byproduct of maintaining the Delta as a permanently freshwater environment (Nobriga et al. 2005). It does not appear to be a significant spawning habitat for native fishes (Grimaldo et al. 2004). Delta smelt are assumed to spawn in sandy or rocky intertidal habitats, but this has never been confirmed (Bennett 2005). Further, the herbicides are principally applied during summer after the delta smelt spawning season. Thus, our principal concern is whether enough toxicant is being applied to harm fish using habitats outside the vegetation beds.***

Evaluation of changes in pelagic fish habitat quality using the IEP long-term monitoring data - This study was intended to characterize the aquatic area in the Delta that has suitable water quality conditions for young of the year delta smelt and striped bass. It determined that quantity of physical habitat has not decreased since 1970. However, the primary parameters defining 'physical habitat' were not clearly stated in the synthesis report and it is important to note that water quality is not the only factor that influences 'physical habitat'. Physical features of the landscape (channel edge configurations, depth, etc) that influence access to spawning or foraging sub-habitats can be very important in estuarine fish production (see Kneib 2003, Mar Ecol Prog Ser 264:279-296) and the configuration of intertidal landscapes are aspects of habitat quality that can be related to the abundance of nektonic populations in adjacent subtidal environments (see Webb & Kneib 2002, Mar Ecol Prog Ser 232:213-223).

- ✓ ***We have revised this analysis since the synthesis report. Summer habitat conditions do seem to have decreased during the period of record and are weakly correlated with fall abundance indexes of delta smelt and striped bass. Specific conductance and Secchi disk depth were the two water quality parameters that significantly influenced the presence/absence of these species using General Additive Model (GAM) methods comparable to Maravelias (1999) and Stoner et al. (2001). We fully agree that physical features, prey availability, etc. also define pelagic fish habitat, including that of delta smelt (Moyle et al. 1992; Bennett 2005). Our intent probably needed to be stated more clearly. We were looking for potential water project influences on water quality that could influence habitat suitability, rather than providing a full niche definition. We are currently very close to completing a manuscript for peer-review on this subject.***

Analysis/summary of recent changes in delta water operations – The emphasis on characterizing recent changes in water project operations in an attempt to account for an apparent step-change in pelagic fish abundance is understandable in terms of political pressure to do something now. However, if POD cannot be understood from an historical perspective, it would seem there is little chance of identifying a specific cause(s) for what is only the last portion of the variation in the record of fish abundance.

- ✓ ***Understanding recent changes is just the first step in investigating water project operational effects. We agree that an historical perspective is necessary and are developing information to accomplish this.***

There are many reasons to be concerned about a focus on a time period that is too narrow, not the least of which is that conditions are likely to change in the near-term as well as long-term future. Also, some fish numbers are already low and it will be difficult to identify subsequent real changes in abundance – either

up or down. The panel was surprised by the lack of data from certain sources that should have been readily available (e.g. fish losses due to impingement and entrainment associated with the operation of power plants in the Delta). It is important to obtain this information and compare it to the historical record of fish abundance based on independent surveys.

- ✓ ***We agree. Updating our understanding of the power plant operations is a major focus of our early 2006 efforts.***

It would be useful to relate salvage densities to regional abundance indices because there is no *a priori* reason to expect the water diversion activities to operate in a density-dependent manner on pelagic organisms (i.e. salvage capture should be proportional to the size of the population). Independent collections of fishes in the net survey stations nearest the water diversion operations should be consistent with the salvage measures of fish abundance. If this is not true, then one or the other (or both) is inadequately representing the status of the fish populations.

- ✓ ***The pelagic estuarine species have distributions that shift geographically based on river flow effects on the position of low-salinity habitat. Thus, the salvage facilities in the south Delta often do not reflect system-wide abundance (Sommer et al. 1997). The salvage facilities also have low and variable efficiency (Brown et al. 1996), making anything other than gross trends (e.g., species invasions/proliferations) difficult to interpret.***

Analysis of historical population dynamics – To date, the focus of this analysis has been on method development and on recent (since 2001) changes in fish abundance indices. The principal source of evidence for a recent general 'step-change' in pelagic fish abundance appears to come from a single model approach (log-linear analysis) applied to the Fall Midwater Trawl Data. Other approaches and data sources either do not support a significant recent step-change or provide weaker evidence for such a conclusion, particularly in the context of earlier historical changes in fish abundance patterns. This only strengthens the position that investment in investigations of the causes of POD should not sacrifice the goal of understanding factors underlying long-term patterns of decline in attempts to respond to recent short-term variation in the populations.

- ✓ ***This method has been revised and submitted for peer-review. The revised analysis suggests there have been numerous species abundance step-changes both upward and downward. Several fish appear to have undergone a downward step-change beginning around 1998-1999. Larger step-changes have occurred previously – for several species, a major step-decline occurred coincident with the* C. amurensis *invasion (Kimmerer 2002).***

NEW STUDIES

Evaluation of delta smelt otolith microstructure and microchemistry – This line of research holds considerable promise for resolving a variety of crucial issues involving growth rates, movements and habitat use patterns involving pelagic fishes. As mentioned previously, use of otoliths to estimate growth rates is far superior to reliance on 'apparent growth rates' from length frequency analysis because otoliths analysis can be used to measure individual growth rates at multiple life stages. Mean or modal sizes of individuals are usually influenced by size-specific (or stage-specific) differences in mortality and reflect the cumulative influence of all physical and biological effects that shape the size structure of the population of survivors. Growth estimates from otoliths, while still measuring only the growth of cohort survivors, are not only more accurate but can provide insights into seasonal variation in growth. Furthermore, data from otolith microchemistry can provide insights into natal origin and movements within the estuary assuming there are reliable data on spatial and temporal variation in the chemical indicators used. These studies should be continued and expanded to other species of interest.

- ✓ ***We agree and are continuing collection of otolith growth data for delta smelt and possibly striped bass with the option of future examination for other species. However, otolith growth rates are time consuming to produce and for young delta smelt they have been very similar to rates calculated via apparent growth.***

Liver histopathology and general pathobiology (starvation disease, and toxic exposure) for pelagic fishes – This study examined pelagic fishes for lesions which could be due to either starvation, disease or exposure to toxic chemicals, but the findings have limited applicability because there is no identified path to link its findings to POD. Further, examining just a few sections of liver could miss significant lesions. More importantly, previous studies have identified other organ systems that are sensitive to the effects of contaminants (nervous system, reproductive system, respiratory system, i.e., gills, excretory system) and none of these were systematically examined. The authors did note that some gonads exhibited intersex conditions in 5-10% of the species examined, a finding of potential significance.

- ✓ ***Contaminants and disease screening will be substantially enhanced in 2006-7 with repeated directed fish collections allowing use of methods and preservation techniques to: identify parasites, fungus and bacteria (skin and gill wet mounts); examine otolith growth; determine the histopathology of brain, gill, body organs and muscle; determine body condition; identify the incidence of replicating viral infection; determine RNA:DNA ratio (growth index). Adult delta smelt and possibly striped***

bass and longfin smelt will be examined for evidence of intersex.

This study may characterize the general effects of environmental stressors on morbidity in pelagic fishes, but what can the findings contribute to a solution? Stressors acting on early life stages would be missed because the affected individuals likely died and are no longer in the population to present their condition. Furthermore, 'the general conclusion of the pathological reports was that findings were not out of the ordinary for wild fish populations.' Based on the results in hand the only conclusion may be that the pelagic fishes are under stress(es) and this in itself is not a great discovery. A multivariate analysis of the histopathology results with other variables might shed some insight into the stresses that impact the livers of these fishes.

- ✓ ***The 2005 work was limited to summer largely for logistical reasons. Histopathology evaluations are planned for early life stages in 2006 and beyond. Granted, there will be difficulty collecting affected young, but a substantial, pervasive stressor should be detectable at some level (we may not be sampling with enough intensity or frequency). If such a stressor is recognized as potentially important, a study design will be developed to better characterize the problem and funding for the work will be sought. The suggestion for a multivariate approach is a good one and in line with our thinking regarding synthetic analyses of the POD data.***

The approaches to understanding the population-level effects of contaminants are much broader than histopathology. For example, one could relate growth and reproduction to contaminant concentrations in tissues, use alternative biomarkers, measure effects of experimental exposures to complex mixtures of contaminants, include much more environmental chemistry, etc. Then there is the real potential for interactive effects of contaminants with disease, food limitation, HABs, etc.

- ✓ ***We agree these could all be very informative approaches. However, it is not clear that toxicity is actually significant to fish populations in the estuary. We are taking a cautious approach to contaminants for two reasons: 1)funding is limited and environmental toxicology studies can be very expensive, particularly when the culprit(s) are uncertain, and; 2) the IEP does not have a strong background in contaminant ecology and we do not want to over-commit ourselves to studies that may be tangential to our needs. We anticipate that protocols using ambient water/TIEs to explore invertebrate toxicity will be a useful first step in evaluating complex mixtures of contaminants. We agree the mixtures may be very important, but there are a nearly infinite number of potentially toxic mixtures, so we prefer to look for big picture trends before committing to evaluation of specific toxic compounds or mixtures.***

There appears to be no compelling reason to continue this work beyond completion of the 2005 sample analyses. Broader based creative approaches are needed to assess the potential role of contaminants in population trajectories. Some of the current work on striped bass shows real evidence of a broader based approach beyond what was done in summer of 2005.

- ✓ ***We disagree with termination after 2005 and agree with taking a broader approach. The 2005 sampling was limited to the summer and fall of a single year, potentially missing important winter and spring events, and presenting only a single set of environmental conditions. It is likely that runoff, herbicide/pesticide applications, chemical discharges, and similarly important factors will change substantially under new environmental conditions. A broader-based approach similar to that for striped bass is being planned for other POD sampling in 2006-7 (see comments above to the first paragraph of this section).***

Analysis of stomach contents, weight and parasites – These studies are time-consuming but could be essential basic information as input to a system-wide tropho-dynamic model if this is a direction later deemed of value. It is unlikely that samples could be processed within a sufficient time frame to track real-time changes in food supply. The simultaneous collection of pelagic fishes and zooplankton in net surveys would more directly address the issue of the availability of an adequate food supply. However, periodically sampling the stomach contents of fish populations would provide information on selective feeding by fishes. Plans to continue this study into 2006 based on the 2005 results is well advised but there is no compelling reason to invest a large effort in the analysis of stomach contents.

- ✓ ***We agree and are doing what is recommended.***

Field survey of *Microcystis aeruginosa* bloom biomass toxicity – Harmful algal blooms (HABs) have affected fish populations in many estuaries undergoing eutrophication. Whether increased nutrient or light availability have been the principal factor(s) in the apparent expansion of Microcystis populations in the Delta remains to be seen. The research to date on *Microcystis* in the Delta has focused on identifying areas where the species is most abundant and in measuring the presence of microcystins in the food web below the level of fishes. It may be more important in considering the continued development of this area of research to establish a connection between *Microcystis* and pelagic fishes in the system. Is there any evidence of an association between fish kills and blooms of *Microcystis* or other potential HABs in the Delta? Historically, *Microcystis* blooms have not been identified as an issue in connection with historical POD. However, the IEP is encouraged to look into remote sensing techniques to develop a more cost effective way to assess the distribution of *Microcystis.* The collection of spot samples can continue to serve as the source

of information to evaluate toxicity. Because there seems to be little doubt as to the toxic nature of *Microcystis* a suggestion is to place more emphasis on aerial distributions and bloom status (rapidly growing versus senescent) rather than toxicity testing. Unless a link can be established between *Microcystis* and pelagic fish population dynamics, continued research in this area may be more pertinent to the development of an ecosystem-level model of the estuary than to the search for the underlying causes of POD.

- ✓ ***We think the remote sensing suggestion is very interesting and may fit well with other water quality monitoring. The spot sampling for toxicity will continue since the array of ambient water bioassay stations overlaps the* Microcystis *bloom in space and time.***

- ✓ ***Increased sampling effort will be made in 2006, particularly in conjunction with on-going summer townet surveys for Delta smelt and striped bass. Dr. Lehman at the Department of Water Resources (DWR) is funded to pursue this work via CALFED Science Program grant. In addition, Dr. Mueller-Solger at DWR received a CALFED Science Program grant to investigate the utility of a submersible spectroflourometer for spatially and temporally-intensive phytoplankton and HAB monitoring in the Delta. Studies focusing on HABs over the larger CALFED area of concern may need resolution at the level of the Delta Science Panel or the Independent Science Board.***

Acute and chronic invertebrate and fish toxicity tests -- There appeared to be little evidence of toxic effects of ambient levels of microcystins in Delta fishes. Although other compounds entering the system may be having negative effects on fishes and/or their primary prey resources either now or in the near future, it is unclear that this area of research will be strongly connected to the current or historical decline in pelagic fish abundance. Short-term assay results may not be linked to any underlying chronic toxicity affecting pelagic fish populations in the estuary. The findings of this study indicated some effects on certain crustaceans (e.g. amphipod, *H. azteca* and copepod, *P. forbesi*) within portions of the watershed, but no significant toxicity to fishes and other crustaceans (e.g. cladoceran, *C. dubia*). The review panel recommends completing toxicity tests as proposed in the 2005 Synthesis Report and 2006-2007 work plan. However, a broader based approach to potential long-term low-level effects of contaminants on these populations is needed.

- ✓ ***The ambient water fish toxicity tests discussed in the Synthesis Report included a single set of samples. We are not comfortable drawing any firm conclusions from those data. However, it is unlikely we will find a direct* Microcystis *effect on the test fishes because the fish tests are scheduled to occur during spring/early summer (prior to the bloom). To date, the test fish also have not overlapped substantially in space or time with the bulk of the* Microcystis *bloom. Thus, our concern regarding***

Microcystis ***is not direct toxic effects. We agree that next steps beyond 2006-2007 will need to evaluate low-level, long-term toxicity. We anticipate our initial studies will help guide the timing and location of future evaluations.***

Striped bass and delta smelt fecundity estimates -- Changes in individual fecundity do not appear to be related to POD, though population fecundity (due to low population sizes) will undoubtedly affect the speed with which pelagic fish populations recover from their historically low levels. These data will provide important input in the development of model of population dynamics, but appear to be sufficiently predictable to allow acceptable parameter estimates without additional sampling. The review panel recommends proceeding as proposed in the 2005 Synthesis Report and 2006-2007 work plan to complete the fecundity estimates. Spot checks of fecundity could be conducted to make sure that fecundity has not dropped and if yes, intensify this program. Otherwise do not expand the estimates until signs of lowered fecundity emerge.

- ✓ ***We agree.***

Trends in benthic macrofauna biomass – With exception of some information on *Corbula* populations, particularly in the vicinity of Suisun Bay, there was little information on the benthic assemblages or their potential role in POD. Obtaining a sufficient number of benthic samples and the time involved in sample processing, can make this a very tedious source of information. While essential for developing linkages between benthic and pelagic portions of the system, this area may best fit into long-range plans for development of an ecosystem model of the Delta. The review panel recommends completing the sample analysis as proposed in the 2005 Synthesis Report and developing a refined sampling program for 2006 if warranted based on the 2005 results.

- ✓ ***The IEP benthos monitoring element is currently in the final stages of a three-year program review. Spatially intensive surveys and retrospective data analyses have been carried out as part of this review and results are currently in preparation for publication. Recommendations for a modified monitoring design based on the study results and several review workshops will be submitted for IEP and SWRCB approval within the next few months. In addition to continued monthly monitoring at six historical long-term stations, the modified design would include annual or semi-annual (spring and fall) spatially intensive monitoring following a spatially-balanced, probabilistic sampling design (Generalized Random Tessellation Stratified (GRTS) design). The new design would enable better estimates of benthic population abundances and process rates, including clam (*** **Corbula amurensis** ***and*** **Corbicula fluminea***) grazing rates on a Delta-wide and regional basis. This would help investigate the "Bad Suisun Bay" hypothesis and benthic-pelagic linkages in general. Resources for the*

costly benthos sample analyses would be freed up by discontinuing monthly monitoring at four historical fixed stations. However, it is currently unclear if sufficient vessel and field staff time would be available to conduct these surveys during the "POD season."

ONGOING STUDIES

Learning from the DSM-2 particle tracking model - The Winter Adult Entrainment (WAE) Hypothesis in the IEP Synthesis of 2005 Work relies on the Delta Simulation Model 2 (DSM2) hydrodynamic model to see if adult fish are being drawn closer to the Central Valley Project (CVP) and State Water Project (SWP) intakes, relative to the situation in the past. The model is a web of 1-Dimensional channels, calibrated to reproduce water transports due to tides, rivers, gates, and water project exports. The DSM2 has a number of advantages and disadvantages. While this approach has provided a good start, on balance, it may be best to phase it out in favor of more sophisticated modeling tools.

- ✓ ***Particle tracking model components of DSM2 were initiated in 2005 by the IEP and are on-going for 2006. Options for utilizing alternate 3D model techniques will depend on funding and availability of appropriate expertise. This may be an item for consideration by the CALFED Independent Science Board.***

DSM2 Advantages:

- It is simple, runs on a personal computer (PC), and can be run by a number of different users in different agencies.
- It is linked to a particle tracking model.
- It has been validated against observed volume transport time series at many locations throughout the Delta.
- In its current form the DSM2 model appears to be adequate to answer questions raised by the WAE Hypothesis.

DSM2 Disadvantages:

- While the model can apparently include the transport of electrical conductivity (which is related to salinity and temperature) as a tracer, it does not have vertical density stratification, and thus may underestimate the potential for up-estuary salt intrusion.
- The documentation of the model leaves much to be desired. The most recent report on model calibration and validation available on the web was: http://www.iep.ca.gov/dsm2pwt/reports/DSM2FinalReport_v07-19-02.pdf. This report had many missing sections, which is understandable since it was a draft. However for a tool such as this to have scientific credibility it needs support from publications in the refereed scientific or engineering literature.

- The model does not include the effects of wind, which could, for short times, substantially alter transports.
- The model does not include temperature as a tracer. Given that habitat for spawning pelagic fish in the Delta has a defined temperature range, this seems like a crucial variable.
- The model, by it very nature as a web of 1-D channels, has difficulty with the hydrodynamics at channel junctions. With model physics of this simplicity, it is hard for the model to decide how much water should go "left or right" when it gets to a junction.
- The model treatment of marshes (e.g. fields reclaimed by dike removal) is extremely simplified, and seems unlikely to be able to address the potential for these areas to enhance primary productivity in the Delta.

Overall the DSM2 model is a good tool for its current uses, but it is not a good framework for any future "ecosystem modeling." A more modern circulation model can include 3-D effects, and can keep track of many more tracers (temperature, nitrate, plankton, even particles with fish-like behavior). Many scientists currently use such numerical tools for ecosystem modeling (e.g. Nutrient-Phytoplankton-Zooplankton-Detritus or "NPZD" models). While this is still far from an exact science, it is precisely the sort of tool that would be useful in exploring the effects of different management scenarios.

- ✓ ***Science Program staff will be asked to help convene an independent Review Panel to evaluate the availability of the identified models and/or expertise for use in conjunction with IEP-supporting efforts. Further elaboration of these models for local use or future investment of resources will need to be coordinated with the Resources Agency, the CALFED Independent Science Board, and the CALFED Lead Scientist. Funding for these efforts may also be solicited or directed via pending Science Program proposal solicitation activities.***

We do not recommend that the IEP undertake the effort to create a full ecosystem model of the Delta right now. However we do strongly recommend that they migrate to the use of circulation models, which could be used as a framework for future ecosystem modeling. Examples of such 3-D circulation models currently in use would be CORIE (Antonio Baptista, Oregon Health & Science University), the Finite Volume Community Ocean Model (FVCOM, Changsheng Chen, UMass Dartmouth), and the Tidal, Residual, Intertidal Mudflat 3-D (TRIM3D) Model already in use for modeling SF Bay and the Delta. All are appropriate for use in the complex channel system of the Delta, and are documented by peer-reviewed publications. Key considerations in choosing a model are that its code be open-source (e.g., the CORIE system) and that it has earned acceptance by the estuarine modeling community.

- ✓ ***See comments immediately above.***

An important issue to consider when migrating to a more complex circulation model is how it will be done in terms of staff. Running such models requires the effort of a dedicated, talented scientist, usually working with a programmer and substantial computing resources (although these don't cost much compared to field work). IEP could consider developing such expertise through collaborations with scientists at research universities in the region.

- ✓ ***Priority status of this item will be discussed with the CALFED Science Program Lead Scientist. Program staff may be available to support increased attention to research developments; support via existing Agency modeling support staff will be encouraged.***

There is a strong trend in coastal and estuarine oceanography to move away from single "expedition-style" experiments and toward "observatory science" which involves integrating real-time observations from different disciplines in a given region. This is funded by NSF through the Ocean Research Interactive Observatory Networks (ORION) program and, on the more applied-operational side, by NOAA through the Integrated Ocean Observing System (IOOS) program. Given the substantial observational effort already underway in the San Francisco Estuary and Delta it would make sense to begin thinking of it in terms of an "observatory." An important step in this direction would be to have a modeling effort such as the 3-D modeling suggested above, that has the potential to integrate and assimilate many different sorts of observations. The benefit is that eventually we will have models of estuarine systems that have real predictive capability, much as is done in weather forecasting.

- ✓ ***We are aware of the trend toward such approaches and IEP staff and contractors have published several studies based on "observatory" approaches (e.g., Kimmerer et al. 1998; Bennett et al. 2002; Nobriga et al. 2004). Real-time data collections also are increasingly incorporated into the IEP monitoring program (e.g., continuous water quality monitoring devices). We are concerned that interactions of flow and fish behavior could require substantial observatory effort to calibrate and validate models (e.g., variation in larval fish behavior to maintain low-salinity zone position under various flows; Bennett et al. 2002).***

The review panel recommends a substantial upgrade of this model that in turn will require more sophisticated analysis of particle tracking and the impact of particle movements on pelagic organisms in the Bay-Delta.

- ✓ ***See comments regarding efforts to improve utilization of available modeling efforts, above.***

South Delta Fisheries-Hydrodynamics studies - This and similar studies are useful in predicting an expected level of mortality under different scenarios

associated with water diversion projects, but to determine the Delta-wide impact of fish mortality associated with water diversion operations, the effects must be placed within the context of the entire population, not just the subset susceptible to entrainment. Impacts of water diversion projects on pelagic fish populations are not expected to act in a density-dependent fashion. The fish salvage data together with entrainment/impingement losses associated with power plant operations should provide a measure of density independent losses due to these uses of the shared water resources.

- ✓ ***These data sources do not provide meaningful measures of fish loss and will not for the foreseeable future. Salvage does not even begin to account for entrainment loss until fish reach about 20 mm in length. Flow and size-based louver efficiency variation and variable predation losses further skew the linkages between entrainment and salvage (Brown et al. 1996). As noted above, power plant data are extremely dated. For these reasons we anticipate that we will continue to rely on qualitative assessments of hydrodynamic model outputs to evaluate entrainment of young fishes.***

Phytoplankton primary production and biomass in the Delta – Shifting algal species, harmful algal blooms, a change from autotrophy to heterotrophy, a shift from a pelagic-dominated to benthic-dominated food web are all key factors influencing the overall health of the Bay-Delta. The phytoplankton studies may be key in revealing the changes.

Research to date in this area has not supported the hypothesis that variation in phytoplankton communities has had substantive effects on food web dynamics that impact pelagic fishes. While there appears to be little direct evidence of a link between phytoplankton primary production and recent POD, unpublished comments from one of the current IEP funded academic partners suggest that historical declines in the quality of phytoplankton resources may be consistent with the long-term POD in the Bay-Delta. The somewhat conflicting evidence from this very important aspect of the food web suggests that additional effort is needed in this area.

- ✓ ***We agree that bottom-up food web linkages have not been supported in the literature (Jassby et al. 1995; Kimmerer 2002). However, the* C. amurensis *invasion greatly reduced the abundance of some organisms at all trophic levels from phytoplankton through fish (Jassby et al. 2002; Kimmerer 2002), suggesting that some bottom-up linkage exists. As noted by the review team, we are aware of mounting evidence for bottom-up linkages that are stronger than reported in the current literature. We have seen unpublished analyses by Kimmerer and others that implicate* C. amurensis *in significant biomass reductions of all trophic levels in Suisun Bay. Most of the fish biomass decline occurred due to emigration of northern anchovy out of the low-salinity zone,***

which hypothetically freed up resources for other fishes. Striped bass abundance indices show a clear step-decline coincident with the* C. amurensis *invasion. This has been over-looked because of the atypical assumption that stock-recruit effects have to be considered to evaluate striped bass population responses to environmental conditions encountered by early life stages (e.g., the egg-juvenile survival mentioned above; Kimmerer et al. 2000; 2001; Kimmerer 2002). Kimmerer has also provided us with a plot of the copepod* Pseudodiaptomus forbesi *abundance in the low-salinity zone. It shows a clear declining trend since its introduction in the latter 1980s. Jassby has shown us unpublished data suggesting a decline of high quality phytoplankton in the low salinity zone. We agree it would be prudent to continue to evaluate the role of trophic connections to both long- and short-term fish declines – particularly in Suisun Bay.

Retrospective analysis of long-term benthic community data – Estuarine benthic communities are notoriously variable and often difficult to sample adequately. The focus here on bivalves increases the likelihood of developing functional links between the benthic and pelagic food webs. Although invasive bivalve species in the system are suspected of impacting phytoplankton production, the connection between known historical shifts in benthic assemblages and POD remains unclear. There are examples of other aquatic systems in which invasions of non-indigenous benthic species (e.g. zebra mussels) have induced major shifts in food web dynamics and ecosystem functioning. A modest investment of IEP resources may yield important inferences related to the long-term decline of pelagic organisms in the Bay-Delta.

- ✓ ***See comments above (Trends in benthic macrofauna biomass; Page 30)***

- ✓ ***This may be the subject of focus for the pending Science Program PSP or for directed action funding at the direction of the CALFED Lead Scientist or Independent Science Board.***

SUMMARY

The long-term data sets developed by this program consist of time series of indices intended to reflect variation in population abundance. They serve primarily as an excellent means for detection of change. To implement studies for determining likely causes and remedial actions, several improvements are required in certain areas of the program including statistical procedures, modeling of physical and biological components of the system, and the development of targets for restoration.

Studies supported to date have helped to address specific questions of potential

importance. Some of these have fulfilled their goals and purpose, while others may need to be continued or expanded. There is need for an expanded effort to fill information gaps on basic natural history of the species targeted by the program in order to characterize and understand POD. Studies involving crucial habitat (e.g. spawning habitat for delta smelt) or the estimation of vital rates (e.g. mortality and growth rates) should be conducted in a spatially-explicit manner to allow spatial pattern mapping and integration into landscape-level models. The review panel considered it crucial that new process studies should augment but not replace the time series surveys that will continue to provide context for the directed studies.

More frequent and focused sampling activity will be necessary to rectify differences in species composition and abundance as determined by tow surveys versus other sources of samples (e.g. fish salvage from water diversion operations and monitoring of impingement and entrainment at power stations, the data for which should be made available). The existing time series is insufficient for evaluating and designing management actions to minimize effects of whatever factor or synergistic suite of factors is found to cause POD.

Explicit restoration goals and targets should be developed for delta smelt and other pelagic organisms of concern. It is crucial to establish an intended target if restoration and maintenance of certain pelagic species populations within the system is the desirable condition. Implicit within the establishment of target ranges for population abundance values is the development of triggers for adaptive management. A worthy goal is to allow the ecosystem to become self-sustaining, but in highly managed systems, such as the Sacramento-San Joaquin Delta, this may be impractical and continued monitoring with triggers for corrective management actions will likely be a necessity.

Laboratory studies of contaminant effects, harmful algal bloom toxicity and starvation on vital rates within different life stages of pelagic organisms should be coupled to yield first-order estimates of life table parameters. These, in turn, will serve as starting points for improved life history models for evaluating the decline and recovery of pelagic organisms in the Bay/Delta region.

Attachments

A. Interagency Ecological Program-related Bibliography

B. IEP/CALFED Science Program Coordinated POD Research Summary

Interagency Ecological Program-related Bibliography

The IEP Bibliography: Journal Articles and Books

Linda Rivard and Ted Sommer, DWR

The following reference list represents our efforts to compile an “official” IEP bibliography for journal articles and books that have been produced through the program’s efforts. The idea was to develop a comprehensive list of peer-reviewed papers to provide a track record of our progress, and as a reference list for the major scientific issues and findings for the SF Estuary. One of our biggest hurdles was to define the criteria that we would use to identify papers for which IEP could claim some credit. These issues were reviewed by the IEP Management Team, who decided that it would be appropriate to include any peer-reviewed paper or book chapter that met one of the following criteria:

1) At least some IEP funding was used for the research
2) Research that relied on IEP samples
3) A study performed using a substantial amount of IEP data
4) The project was an official IEP "Program Element" (e.g. IEP staff, study plan & review process)
5) Papers were published as part of an IEP-sponsored volume (e.g. CDFG Fish Bulletin Salmon Symposium)
6) A paper co-authored by an IEP staff member.
7) Work preceding the formal formation of the IEP that focused on the evaluation of potential water project impacts or the collection of pre-project data.

Based on these criteria, many potential entries were excluded. First, we did not include IEP Technical Reports (see www.iep) or USGS file reports because they did not meet our requirement for peer-reviewed journal or book contributions. We excluded much of the important work from key IEP member agencies such as USGS, UCD and DFG for projects that were entirely funded by outside programs. Similarly, most CALFED-funded projects were not included in the list unless the work was performed as part of an IEP program (e.g. Yolo Bypass and Breach studies). DFG articles on the Delta from the 1960s and 1970s preceded the formation of IEP, but were included because the work focused on the collection of pre-project data and/or collected early data for ongoing IEP surveys. Note that this summary is intended as a work in progress that will be updated regularly and posted on the IEP website. We encourage everyone to send us suggestions for future revisions.

The following papers met at least one of our bibliographic criteria. Studies in which the only criterion met was #3 are identified after the citation (“USED IEP DATA”).

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IEP/CALFED Science Program
Coordinated POD Research Summary

Study Name/Project Title	Lead PI/ Organization	Funding Amount/ Source/Vehicle	FY 2006 Projected	FY 2007 Projected	FY 2008 Projected
Modeling the Delta smelt population of the San Francisco Estuary	Kimmerer, SFSU	$997,027 Proposition 13 SciPrgm PSP	$332,342	$332,342	$332,342
Foodweb support for the threatened Delta smelt and other estuarine fishes in Suisun Bay and the western Sacramento-San Joaquin Delta	Kimmerer, SFSU	$1,170,000 Proposition 50 SciPrgm PSP	$390,000	$390,000	$390,000
Biomass and toxicity of a newly established bloom of the cyanobacteria Microcystis aeruginosa and its potential impact on beneficial use in the Sacramento-San Joaquin Delta	Lehman, DWR	$500,000 Proposition 50 SciPrgm PSP	$250,000	$250,000	n/a
CASCaDE:Computational Assessments of Scenarios of Change for the Delta Ecosystem	Cloern, USGS	$1,662,870 Proposition 204 SciPrgm PSP	$554,290	$554,290	$554,290
Technical Review Panel IEP POD	Moll, UCSD et alia	$125,000 Proposition 50 (?) SciPrgm NCB (?)	$125,000	$0	$0
Technical Review for the IEP POD issues relating to contaminants and aquatic herbicides	Connors, SFEI	$77,000 Proposition 50 (?) SciPrgm AB 446 (?)	$77,000	$0	$0
The application of otolith geochemistry to determine strock structure, survival, and the relative impact of water exports on the threatened Delta smelt	Hobbs, UCD	$228,750 CSGCA Science Fellows Prgm	$76,250	$76,250	$76,250